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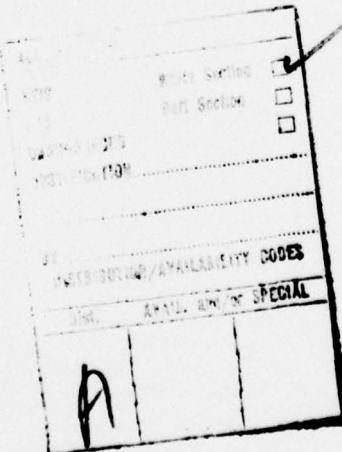
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Original Study

From the Surgical Ward of the Herzberg/Elster District Hospital (Chief Physician: Special Docent Dr. med. habil Ch. Drescher)

RHYTHM AND SURGERY

By Ch. Drescher

With Four Illustrations

New scientific research results have pointed up the dependence of organic life on cosmically determined phases. Considering nature as it surrounds us, we cannot fail to realize that everything that happens takes place in the form of waves, in a constant up and down, whereby the length of the period fluctuates between decades and seconds. Man's life is subject to numerous time periods ranging from years and months all the way to days. Very many rhythmic processes in the human organism follow the alternation of day and night in terms of their frequency, in other words, they are repeated during a period of 24 hours.

By rhythm we mean the return, not of identical things, but of similar things, at regular time intervals. We speak of periodicity when an identically recurring process reveals interruptions (Klages). Rhythm is a wave-like continuing process while periodicity is an interrupted one (Meninger-Lerchenthal).

The biological rhythm is three-dimensional. While the stroke of a machine is rigid and varies only in terms of speed, we can say that the rhythms are variable both in terms of the degree of fluctuations and in terms of the extent of the intervals (Knigge).

The 24-hour rhythm is of decisive significance to the body. Jores was the first to publish basic discoveries on the 24-hour [circadian] rhythm 30 years ago. The following basically important results sprang from that:

1. The day-and-night rhythm is not the cause of the circadian rhythms; the latter instead develop endogenously.
2. Control normally happens only around a middle or average value. The rhythm can be accurately adjusted through an exogenous timer.
3. The amount of the amplitude varies individually and also fluctuates around an average value in each individual person.
4. Major deviations as well as the suspension of the rhythm thus can be termed pathological.

5. A characteristic change in the duration of periods has been described for many diseases.

6. The discovery of maximums and minimums is important in judging diseases.

The waves of the rhythms do not run synchronously in the individual functions. Probably, a simultaneous maximum or minimum would not be tolerable for the organism in many functions. This seems to speak against a central regulation of rhythms. It is to be assumed that they take place according to a fixed rhythm plan.

When the time periodicity is shifted, we gradually get an adaptation of the rhythm of the organism in which the acme is shifted daily by a certain amount until the accustomed phase has been reached again. We know many physiological processes which are subject to regular periodic fluctuations. These were observed in individual cells, for example, in the activity of enzymes and nucleic acids, furthermore in organs--stomach juice, bile secretion, hormone discharge--and furthermore in the entire organism, such as motor activity, temperature, and physical and psychological capacity.

Reaction to changes in the environment varies in the individual rhythms. Their control for cells and organs is probably autonomous. Plants and animals have the ability to orient themselves throughout the course of the day. This physiological ability has been called the "time clock" (Bünning). It is not only always uniformly triggered by impulses working from the outside but also appears due to cyclic work processes.

Man also has this [built-in] time clock and depends on it in terms of his daily rhythms. This time clock works for days and weeks independently with a tolerable error margin, corresponding to the endogenous day-and-night rhythm. When an individually varying maximum stress is exceeded, it fails and must again be regulated through an exogenous time meter. There are differences of opinion as to the existence of cellular or central control. Experiments by Bünning on isolated individual parts of leaves revealed a continuation of the day-periodic growth fluctuations. Furthermore, endogenous day-periodic algae were found.

In vertebrates, especially in man, many researchers assume that the daily rhythms are centrally controlled. Thus, Aschoff is of the opinion that the seat of the control [mechanism] is in the CNS. Jores points out that adrenalin and increased sympathetic tonus control the day, while melanophore hormone and increased parasympathetic tonus control the night and thus constitute the cause for the circadian rhythm. This is contradicted by the circumstance that a disturbance in the rhythm--for example, by reversing the alternation of light and dark--in many periodic body functions does not become effective uniformly but rather at differently long time intervals.

The circadian rhythms fluctuate independently of each other according to laws which are put out by a central control. This control takes place

through the vegetative nervous system upon instruction from the vegetative centers located in the diencephalon. They are subject, first of all, to the influence of the endocrine glands, of which the hypophysis and the adrenal gland are antipodes due to polar tension and they in particular control the day-and-night rhythm. In addition, the hypophysis here is particularly subject to the effect of light. Becher discovered the presence of vegetative ganglia cells in the cornea. Hollwich proved the effect of light on the central regulation of the rhythm. From the fasciculus opticus, a part of the control runs from the chiasma via the nucleus supraopticus into the neurohypophysis and allows the light to become effective there vegetatively. Hollwich called this control the "energy" portion of the line of sight. Many observations permit us to conclude that the circadian rhythms can also be triggered chemically because they are partly tied to fluctuations in the metabolism. The change of an assimilatory day phase and a dissimilatory night phase is rather striking. For the organism, these rhythms imply the establishment of favorable conditions for biochemical reactions in the cell. Jores observes: "That the daytime periodicity of man is a process which in many instances is interdependently controlled in an endocrine-vegetative manner and which partly is regulated endogenously through a built-in clock while it is also partly regulated by terrestrial and extraterrestrial processes."

Meninger-Lerchenthal said: "One could construe the energy portion of the line of sight as a circuit between sunlight as medium, in which man lives, and the endocrine system, with a connection to the vegetative nervous system, in other words, to the vegetatively endocrine roots of the psychophysical component."

Animals react differently to the same harmful action [stimuli], depending upon the exact time of the circadian period in which the damage is inflicted. American experiments have revealed this: when rats were irradiated with x-rays at a steady dose, the animals irradiated at around 0900 survived for more than 130 days while the animals irradiated at around 2100 died after 13 days. Treatment with cancer-producing substances also revealed an astonishing result. Hamsters, who had been injected with dimethylbenzanthracene at 1200, 15 weeks later developed cancer in almost 90% of the cases (Wobus). Likewise, a differing reaction of the organism to toxins was observed, depending upon the time of day when the stimulus became active.

Considering the daily rhythm is very important to the surgeon in a diagnostic and therapeutic respect. The following questions come up:

1. How should we explain and judge the reaction of the body which varies according to the daily rhythm?
2. Does the time of the acme of the physiological period signify a state of increased defense readiness while hypacme signifies a state of weakness?
3. What conclusions can be derived from this for our practical surgical actions?

#### 4. Is there any connection between rhythm and regeneration?

With respect to 1. If we look for the cause of the differing reaction of the living organism to the same exogenous damage during various phases of the physiological rhythm, we must turn our attention to the vegetative nervous system. We distinguish the sympathetic and parasympathetic portion. The function of both of these parts is overwhelmingly opposite.

Both nerves have regulative centers in the midbrain (Hoff). Their function takes place within a circadian rhythmic alternation depending on the wake-sleep rhythm of the organism. During sleep, the parasympathicus predominates while during waking hours the sympathicus predominates.

The above mentioned striking serious damage to animals due to these same noxious stimuli obviously took place during the trophotropic parasympathetic phase. This brings up the problem as to just how far observations in man reveal a reduced resistance during the trophotropic phase. Here, the question as to the real cause of the wake-sleep rhythm is unanswered.

The alternation in the adjustment of the vegetative nervous system is not absolutely tied to sleep but rather runs parallel to it (Völker). We get the maximum value for the 24-hour rhythm according to the sympathicotonus for the pulse, temperature, blood pressure, urobilinogen secretion in the afternoon at 1600 while we get the minimum value during the hours after midnight. Colics, collapse, glaucoma, the start of labor pains, brachialgia nocturna, cramps in the calves--these appear frequently in a periodic manner during the night. Reimann compiled a large number of periodically appearing disorders as "periodic disease."

We can be sure that damage--which hits the body in the trophotropic phase of the parasympathicotonus--has a stronger effect than during the ergotropic phase of the sympathicotonus. Because the rhythm spontaneously continues to oscillate into the ergotropic phase, it is very difficult to explain a big difference in the damage only through the parasympathicotonus. In addition to nerve switching, there must--during the vulnerable phase of the rhythm--be a possibility of serious, abnormal damage which continues to act without any time limit and which leads to strikingly differing results, as observed in the above mentioned animal experiments.

It is known that many physiological functions follow the circadian rhythm. Thus the effect of fermentation takes place under the regulation of hormones which influence the activity of the individual enzymes. This is a complicated process in which temperature, hydrogen ion concentration, and the activity of vitamins cooperate. The rhythmic alternation in the activity of the ferments which are important to illumination was observed in the case of photogenic (luminous) algae (Bünning). The daily rhythm of the liver was discovered by Forsgren. A similar rhythmic ferment secretion was also noted in the pancreas (Balzer and Werner). Menzel had this to say on that point: "There is hardly a function of the human body which does not reveal a difference between day and night."

With respect to 2. At the beginning of this work we pointed out that not all rhythmic functions reach their high points and their low points simultaneously but that they rather take place in a manner individually adapted to a rhythmic plan (Menzel).

A complex control system is required which, in terms of its operation, is integrated into the dominant image of the day-and-night phase, with optimum effect, during a span of time set aside for this. If there is a change in the image, for example, in case of protracted nighttime work, many body functions may retain the old phase position of their rhythm over a considerable interval of time, although the sleep rhythm will be completely reversed (Aschoff). During the interim, during the stage of disrhythmia, this will lead to damage.

Irregularities in the rhythm under certain circumstances have serious consequences if they hit an organism that has been weakened by illness or accident.

The organs are coordinated with each other not only in terms of their performance but also in terms of the working time that is best for them. This means that it is necessary to consider a therapeutic support for the individual organ functions. Therapy must be adjusted to the normal rhythm of the healthy individual.

Jores was against administering bile-moving medication in the evening because the switch in the liver function toward glycogen formation has already started by that time and because the liver performs in a refractory manner. Analgesics should not be prescribed equally for daytime and nighttime in a standardized fashion.

Pathological changes--which appear in company with menstrual phases--are specifically treated from the gynecological aspect with endocrine medications.

Heinzen refers to vitamin E as a regulator of the function of the hypophysis. He treats rhythmic disease states--which spring up as a consequence of the disregulation of the hypophysis-midbrain system--by administering vitamin E shots. This is an attempt to influence and regulate the disrhythmia at the place where it arises.

In physical therapy, the varying distribution of the blood between day and night is important during massage. Lampert reports that the effect of the massage depends on the patient's rhythm.

We are just at the beginning of a eurhythmic therapy which will have a fructifying effect on the way we use our medications.

With respect to 3. Let us now turn to the special problems which spring from the consideration of the rhythm with regard to the surgeon's activity. During the preparation for the operation we have a requirement here and that

is, in case of operations which are not urgent, to consider the natural rhythm of the organ functions and, if it is disturbed, to regulate it back to normal as much as possible. Our fast-paced modern life has taken hold of people in all occupations and age brackets and, regardless of the body's natural rhythm, demands a tremendous effort and performance at all times. Often, the rather tight period of recovery becomes an additional burden here. More and more frequently, the surgeon faces the difficult task of performing operations on people who suffer from dangerous vegetative-nervous irritations. For the most part these are caused by the disturbances of the daily rhythm and they produce all kinds of dangerous consequences of disrhythmia. Here it is advised to restore the natural rhythm of vital functions if at all possible prior to the operation. A serious stay at a therapeutic facility, with compulsion for a simple, natural way of life, can very favorably influence the threat which would otherwise derive from the operation. Klatt points out that it is advantageous, especially for patients suffering from nervous vegetative dystonia, to use their daily vacation time for the eurythmization of the elementary forms of life. Even in the case of patients who have been admitted for urgent operations, an effort should be made extensively to consider the special life rhythm. The fact is that great fear or anxiety has a strong rhythm-disturbing effect on the individual and causes physical damage through the vegetative nervous system. It is therefore a natural duty of the doctor to dispel that fear and to bring about calm and confidence. Here he often comes into a conflict which cannot be resolved if he wants to follow up on the extensive duty to explain the situation to the patient as required by law.

During the preparatory period and especially during the night prior to the operation, it is absolutely necessary to eliminate any pain and to induce sleep by means of medication.

In general, operations that are not urgent are performed during the morning hours or early afternoon hours. This is also the best time to comply with the rhythm requirements. In central operating facilities it is the custom, here and there, to have operations performed throughout the day, late into the evening, in order to use the facility for the various disciplines. This method cannot be approved from the viewpoint of eurythmia. The results of American animal experiments, which were mentioned earlier, should persuade us to pay more attention to the time factor in keeping with the rhythm.

Special attention must be devoted to the observation of eurythmia primarily during postoperative treatment. Here we come to the problem of rhythm disturbances due to strong acoustic stimuli which threaten the normal life rhythm of the healthy individual and especially the ill individual to an extent not imaginable earlier.

The natural concern of doctors and nurses to keep noise away from patients who have been operated on is doomed to failure if the hospital is located within the range of street and air engine noises. The sudden, explosion-like bang as an aircraft breaks the sonic barrier [sonic boom] is probably one of the biggest possible acoustic stimuli which can act upon the

individual in peacetime. Here we must clearly realize how the development of technology over the past years has clearly outrun all human planning. This results in serious conclusions as far as the surgeon is concerned. If the trophotropic phase of the rhythm is abruptly interrupted during the evening and nighttime hours by crass aircraft noises, there is then a sudden switch to the sympathetic tonic ergotropic phase. Here one can expect the occurrence of an emergency reaction according to Cannon with a maximum increase in sympathetic excitation. If such a stimulus takes place several times during the day and the night, then we can expect a disastrous disrhythmia. The manner, in which the vegetative nervous system responds to stimuli, depends on the initial excitation state value law of Wilder such as it prevails at the moment of the stimulus. Here there may be a reversal of the direction of the stimulus effect, as was proved by Wetzler. In other words, repeated sympathetic stimuli, going beyond a certain high point, can suddenly change over into the opposite parasympathicotropic tonus situation. They then however bring about a state of complete disorder as the last consequence of the disturbance of the rhythm.

It is quite obvious that this can lead to sudden embolism and heart infarcts. Moreover, we can expect a general decline in the organism's resistance because the enzyme budget and thus the energy budget are severely damaged. At birth, a woman is very sensitive to abrupt disturbances of the rhythm. We must demand that the more or less disturbed eurhythmia be considered in all fields of medical statistics.

The surgeon now faces the task of coping with the difficulties described. It seems necessary--depending upon the degree of seriousness of the anticipated unavoidable acoustic stimuli before and after an operation--to achieve the uniform attenuation of the vegetative nervous system by means of medication. It is recommended to set up a standardized treatment scheme for these attenuated patients.

Research results on nighttime work and shift changes are important to the organization of hospital operation. Doctors and nurses are heavily over-worked especially in medium-sized and small facilities. Pierach described the problem of fatigue due to night work and shift change as a consequence of the exhaustion of the vegetative reserve. Menzel pointed up the danger of increasingly frequent mistakes by night workers.

With respect to 4. It should be examined whether rhythm and regeneration depend on each other. Regeneration is an energy-demanding process. A rhythmic functional minimum and maximum were observed for the biocatalysts which play a great role in energy metabolism. In this connection, the work by Richter and Pierson on the enzymes of *Hydrodictyon* and the way they are influenced by the periodicity of illumination is of fundamental significance. Here we are going to the essential aspects of this work: in the green alga *Hydrodictyon reticulatum* it was observed that growth and metabolism follow a rhythmic pattern which is closely connected with the alternation between light and dark. It was examined whether synchronous changes in ferment activity can be proved in cell extracts which were obtained during various

phases of the rhythm. Among other things, sour phosphatase and catalase were observed and their activity was tested in various rhythm phases. The following results were obtained:

The sour phosphatases run through one activity minimum, each, in light and in dark. The catalase activity reveals a minimum during the time when it is light and a maximum in darkness. This clearly proved the periodicity of enzyme activity. Similar enzymological results were achieved by Bünning and Ehrenberg.

The regeneration of tissues takes place amid the harmonious cooperation of the biocatalysts. This is why disturbances in their rhythm patterns are bound to have a harmful effect on regeneration.

As a model for a disturbed rhythm pattern in regeneration processes we might mention Sudeck's bone dystrophy. For many years, the results of the very active treatment methods employed in this disease were disastrous. More meaningful treatment was gradually developed along with a profound insight into the pathological events here. In Die Chirurgie des Traumas [The Surgery of Trauma], Mörl writes the following on Sudeck's disease in discussing fractures and luxations:

"In causal genetic terms there is still no uniform opinion in spite of numerous research studies. . . . The natural adaptation processes however are derailed into the pathological only when there are disturbances in the superordinate mechanism. . . . Just what kind of central misregulation we have here is one of the unanswered questions. But we are probably dealing here with complex mechanisms of a humoral nerval kind which concern both the hypophysis-adrenal gland axis and the course of the vegetative-nerval control and which are extensively tied to each other in the midbrain-hypophysis system."

Here, in just a few words, is the prevailing opinion of instructors on the pathogenesis of Sudeck's disease. Mörl then brings up the following four therapeutic requirements:

1. Making sure that the primary focus can heal without being disturbed;
2. Keeping all superfluous and harmful stimuli away;
3. Eliminating pain;
4. Measures to improve blood circulation.

These theses represent logical demands which the science of surgery has derived from the bitter experiences of manifold erroneous treatment in past years.

We completely agree with the theory mentioned above but we are of the opinion that one could gain a deeper, more comprehensive insight into the

pathological processes described if one were to contemplate them from the viewpoint of the disturbed rhythm pattern of numerous organic functions. The effect of great force [violence] upon the body in serious traffic accidents is entirely likely to shake up the substance of the personality in depth and to disturb the harmonious rhythm of vital organ functions. In addition to a quite natural and expert organ supply [support], the surgeon also has the task of achieving the rapid and complete regeneration of the damaged tissues through eurhythmic therapy.

The therapeutic requirements for the treatment of Sudeck's disease, listed by Mørli, fit meaningfully into such a eurhythmic therapy. From the viewpoint of the rhythm pattern, we can furthermore clearly explain the fact that the picture of Sudeck's dystrophy develops only in a small percentage of the patients who apparently are predestined for this.

The initial value of the rhythmic harmony in a personality plays a great role in overcoming the consequences of an accident. Most of the time, these are patients with vegetative dystonia and with an already extensively disturbed rhythm pattern, who as a result of the accident very easily slip into the stage of a fatal disrhythmia. Here it is clear that even a eurhythmic organism with a good starting value can be placed into the state of disrhythmia even after slight injury to the bones through repeated, numerous and strong stimuli such as the previously used therapy of fractures entailed.

The main symptom complex of thorough and effective blood circulation disturbance and the formation of edema during the first stage of Sudeck's disease can also be explained in light of the rhythm disturbance. On the basis of many observations we know that the cardiovascular system at night reacts with a definite rhythm change in the circulation, the blood pressure, and the pulse beat. The functional minimum occurs during the hours after midnight. Vegetative dystonia goes hand in hand with a stigmatization of the cardiovascular system. It is thus understandable that, in this group of persons, there is a special danger of stepping up the rhythm amplitude into a pathological reaction as a result of [reaction to] the accident. Wilder's law on the significance of the initial value provides an explanation for the post-traumatic vasomotor derailment with subsequent capillary damage and edema formation. Scheibe is of the opinion that vascular derailments in the Sudeck Syndrome are definitely dependent upon the basic reactions of the vegetative nervous system. This view likewise can easily be incorporated among the overall concept of rhythm disturbance. Therapeutically, it is important that--upon the slightest indication of abnormal capillary reaction with strong edema formation--a corresponding eurhythmic therapy be immediately initiated with attenuation, keeping all stimuli away, and making sure that the blood circulation will be improved in a careful but effective manner.

Thus the Sudeck Syndrome seems to us to be a particularly impressive example for the significance of the rhythm pattern.

Our opinion, to the effect that the regenerative processes depend heavily on the rhythm, is to be examined now experimentally according to the

example of the way in which fractures heal.

#### Experimental Part

Animal experiments were conducted on identical young roosters having the same weight.

Experimental setup: in two series of ten animals, each, fractures of the right metatarsal are made after light narcosis. The padded splints were then carefully applied to the fractures. The first animal series (series A) is so kept under completely normal conditions, with sufficient room to run around, that the animals' day runs from 0700 until 1900. The animals were fed twice a day at 0700 and 1900 with a rather varied diet of wheat, potatoes, rice, and fresh green fodder.

In the second series (series B), the normal day and night rhythm is reversed. In a large room, which is completely dark, these animals are so kept, with sufficient possibility for running around, that the day lasts from 1900 until 0700 and this is followed by artificial nighttime for the next 12 hours. We used 200-watt bulbs to produce bright light. In order to influence the animals acoustically in terms of the usual day, 15 big alarm clocks are set up in the experimental room and they are set to go off at short intervals between 1900 and 0600. The animals were fed in the above-described, varied form at 0700 and 1900.

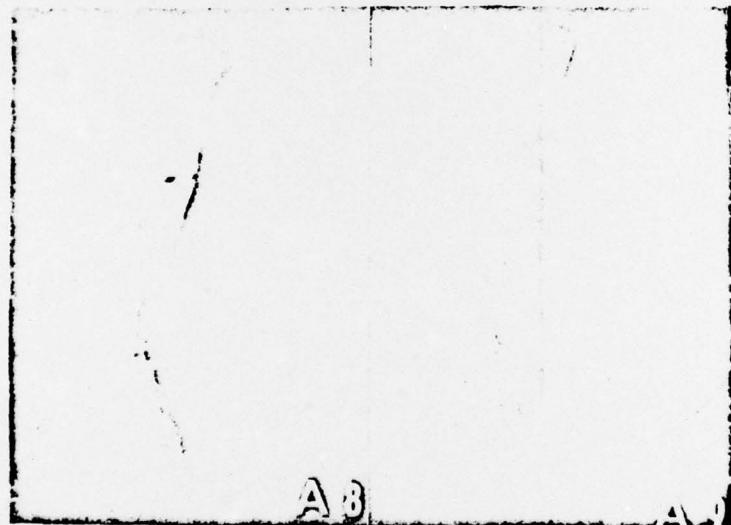


Figure 1

Figure 2

Figures 1 and 2. Fractures in animals, whose rhythm was not disturbed, after 14 days. Clearly visible: periostal and endostal callus formation.

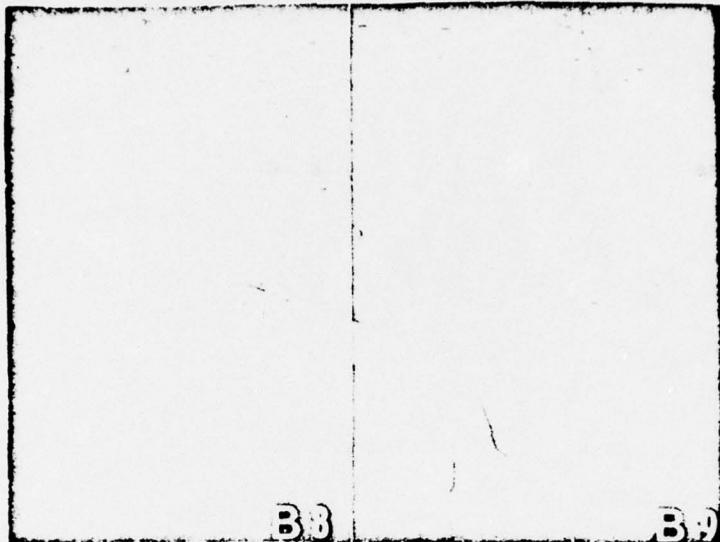


Figure 3

Figure 4

Figures 3 and 4. Fractures in animals whose rhythm was disturbed. There is no callus formation whatsoever.

During the next several days we observed that the little roosters, whose rhythm had been disturbed, made much worse progress during running than the roosters kept under normal conditions. After 8 days, the animals in series A, whose rhythm was not disturbed, ran around and jumped around like the healthy animals. They fought over their fodder and we had the first cock-fight between the young roosters. At the same time, the running and jumping of the animals whose rhythm was disturbed, those in series B, did not return to anywhere near normal. In contrast to the animals of the other series, these animals slept on the ground and there was no fighting between the young roosters. Both animal series consumed their fodder in the same effective manner.

All animals were killed after 14 days. Upon removing the splints and bandages we found the fractures of series A--the animals whose rhythm was not disturbed--to be clinically solid. The fractures of series B on the other hand revealed definite crepitation upon cautious examination. X-ray pictures were then taken of all fractures. The x-rays revealed definite differences in both series of animals.

All fractures in series A revealed adequate endostal and periostal callus formation.

In animal series B on the other hand--the little roosters whose rhythm had been disturbed--the callus formation was minimum, except in one animal.

All rooster bones were examined histologically at the pathological institute of the Cottbus district hospital. (I am indebted to medical

counsellor Dr. Wolf for his kindness in supporting me once again here.) In this connection, definite differences in callus formation at the fracture points were found in the animals of series A and the animals of Series B. The differences were visible in all animals although they varied in the degree of development. The A animals, whose rhythm was not disturbed, revealed a clear and very well developed callus formation at the fracture points which extensively bridged and consolidated the fractures. In the B animals, those with the disturbed rhythm, the callus formation was just beginning. Only here and there could one see individual small cartilage islands which in some cases developed into bone parts that had shifted into the fracture points so that the consolidation here by far was not yet as pronounced as in the animals of the A series.

The animal experiments show how it was possible to prove through x-rays and histological examination that one rhythm disturbance alone is enough to bring about a definitely delayed bone fracture healing in chickens.

#### Summary

The importance of rhythm in the normal function of the human body is pointed up. The differing course of the rhythms of the individual organs is indicated and the control of the body rhythm is discussed. Here, the leading role of the vegetative nervous system and the diencephalon is emphasized.

Damage due to failure to observe the rhythm in connection with operations is explained. General principles are set up for surgical action in order to meet the dangers of disrhythmia. The special role of eurhythmia in the regeneration of damaged tissues is illustrated with the help of fracture treatment, giving special consideration to Sudeck's dystrophy. To prove this thesis, artificially created fractures on chicken legs [sic] were treated under eurhythmic and disrhythmic conditions. The comparison of the results achieved proves the great significance of eurhythmia for the regeneration of damaged tissues.

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